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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

In the Matter of)
)
Inquiry on Competitive Bidding Process) WT Docket No. 97-150
for Report to Congress --)
Competitive Bidding Proceeding)

COMMENTS OF THE AUTOMATED CREDIT EXCHANGE

The Automated Credit Exchange ("ACE") hereby submits the following
comments in response to the above-captioned Notice of Inquiry ("Notice").

I. INTRODUCTION

ACE is an organization that has designed, developed and currently operates a two-sided, electronic trading market for pollution credits in Southern California. Run in conjunction with the Pacific Stock Exchange, and with assistance from faculty at the California Institute of Technology, the ACE market permits buyers and sellers to place several alternative bids/offers on individual pollution credits in their order of preference (sometimes referred to as "contingent" bids), as well as to submit package offers (sometimes referred to as "combinatorial" bids) for combinations of credits tailored to individual bidders' business preferences.¹ ACE conducts

¹ Pollution credit trading evolved out of the Southern California smog regulations of the early 1990's. Companies were required to curtail their emissions emitting no more than the number of credits (limited licenses to pollute) they hold. The companies were granted an initial allocation of credits -- a declining balance whose initial point was based on past output. These credits are allowed to be traded freely among companies. Companies that find it economically or technologically infeasible to make new reductions can buy credits from companies that can make extra reductions more cheaply. The ceiling on pollution credits is lowered over time, making credits for future years more valuable down the line

quarterly markets using the Internet, a proprietary computer algorithm and proprietary bidding software. ACE's contingent package bid trading process has experienced tremendous success in the twelve emissions trading markets that ACE has conducted to date in the South Coast Air Quality Management District -- markets that have encompassed the trading of over twenty million credit units. The ACE market is the only two-sided package bid auction system of its kind operating in the world today.

When Congress granted the Commission explicit authority to use competitive bidding as a means to license the use of radio spectrum, Congress also required the Commission to conduct a policy inquiry, and to submit a report to Congress by September 30, 1997, regarding the general effectiveness of competitive bidding as a license assignment tool; the advantages and disadvantages of different competitive bidding methodologies the Commission has considered; and the degree to which competitive bidding has led to improved license assignment efficiency and the prompt deployment of new spectrum-based services into the marketplace.² Congress also has asked the Commission to recommend any statutory changes needed to improve the competitive bidding process.³

ACE believes that the preceding four years have shown that the Commission's implementation of its auction authority generally has led to the successful pursuit and

as companies attempt to maintain compliance. See P. Brennan, "Pollution for Sale: Buying and selling smog credits is becoming significant in long-term business planning, Orange County Register, May 21, 1996, at C1; A. Adelson, "Market Opening on Internet for Pollution-Credit Trades," The New York Times, April 13, 1995, at D2.

² See 47 U.S.C. § 309(j)(12); *Notice* at I.3)-4).

³ 47 U.S.C. § 309(j)(12); *Notice* at I.4).

achievement of many Congressional policy goals in granting auction authority to the agency.

The Commission to date has completed fourteen auctions that have resulted in the assignment of over 4,300 licenses for spectrum-based services,⁴ and has succeeded in proving that auctions indeed make sense as a spectrum licensing mechanism. ACE also believes, however, that there is room for improvement in the Commission's present auction process. Indeed, there is a statutory mandate for the agency to continue to pursue and use innovative auction methodologies to license spectrum-based services.⁵

The Commission in the past has considered, and is again exploring,⁶ the implementation of a combinatorial/package bidding method of allocating radio spectrum licenses. A package bidding system contains all of the informational advantages of the Commission's current simultaneous multiple round auction methodology -- which attempts to provide maximum information to bidders of license values during the course of a given auction -- but also provides bidders with the ability to submit bids in any type of package that they wish, with no restriction on possible combinations of licenses or the size of orders that may be entered.⁷ Three years ago, the Commission acknowledged advantages to a packaged bidding

⁴ Notice at I.4).

⁵ 47 U.S.C. § 309(j)(3).

⁶ See Amendment of Part I of the Commission's Rules -- Competitive Bidding Proceeding, WT Docket No. 97-82, Order, Memorandum Opinion and Order and Notice of Proposed Rulemaking (released Feb. 28, 1997). The Commission also evidently has awarded a contract for a study and recommendation paper regarding theoretical and applied combinatorial auction designs, including an assessment of the advantages, disadvantages, technical feasibility and cost of implementation of different approaches. See Solicitation No. 2700-FCC-97-R-0004 (issued Dec. 19, 1996).

⁷ Thus, for example, if the Commission were issuing 3 spectrum licenses, A, B and C, the Commission's current methodology would run three separate auctions for these licenses simultaneously. While it is possible to aggregate those licenses in real time due to the

approach in both promoting the efficient aggregation of licenses and in simplifying bidding strategy,⁸ but rejected the methodology as too complex and difficult to implement.⁹

The Commission's rejection of a package bidding methodology may have made sense in 1994, when the Commission was taking its first steps to implement its auction authority (and to conduct spectrum auctions under very tight time deadlines). However, the time is now ripe for the Commission to re-examine a package-bid approach. ACE's success in operating a *two-sided* (both buyers and sellers) electronic market using package bidding -- a more complex implementation proposition than a one-sided auction (*e.g.* only buyers bid on the items for sale) -- has shown that a workable, user-friendly system of package bidding can indeed be implemented.¹⁰

simultaneous characteristic of the auction, which reveals the bidding activity on and values of each license, bidders are still required to bid on individual licenses that may be worth less to them if they cannot obtain them as a package. Thus, if a bidder only wishes to win license A if she can also acquire license B, the Commission's current system requires the bidder to risk money on both licenses, with a significant risk that she may win only one license and be outbid on the other. By contrast, a "packaged bid" permits the bidder to submit a bid *only* on licenses A and B as a package if she wishes, with no individual license bids and with no risk that she will pay money for anything other than her preferred outcome, *i.e.*, getting both licenses, A and B, as a package. *See infra*.

⁸ In the Matter of Implementation of Section 309(j) of the Communications Act -- Competitive Bidding, *Second Report and Order*, 9 FCC Rcd 2348, 2365, ¶99.

⁹ *Id.* at 2366, ¶ 102.

¹⁰ In the Commission's recent order setting the rules for its upcoming auction of Local Multipoint Distribution Service ("LMDS") licenses, the Commission adopted a simultaneous multiple round auction design as the method "most likely to award licenses to the bidders who value them most highly and to provide bidders with the greatest likelihood of obtaining the license combinations that best satisfy their service need." The Commission also suggested, however, that this decision was made because "[w]e do not have the operational capability to use combinatorial bidding." In the Matter of Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, To Reallocate the 29.5-30.0 GHz Frequency Band,

ACE believes that a package bidding system can achieve significantly better results than the Commission's current simultaneous, multiple-round auction methodology, particularly in the aspects of increasing the closing speed and the license assignment efficiency of particular auctions. ACE strongly believes that the availability of package bidding will both promote the more rapid development of new communications services and technologies, and will likely recover to the U.S. Treasury additional value for the public spectrum resource as measured by auction revenue.¹¹

The Commission has the mandate, under Section 309(j)(3) of the Communications Act, to "design and test multiple alternative" auction methodologies "under appropriate circumstances."¹² As the agency conducts this policy review of its competitive bidding designs and auction procedures, ACE urges the Commission to take the necessary implementation steps to introduce package bidding as a spectrum assignment mechanism into the wireless marketplace as soon as possible. ACE below submits information that it hopes will be useful in implementing and evaluating future auctions, and in particular auctions that will use a package-bid methodology.

To Establish Rules and Policies for Local Multipoint Distribution Service and For Fixed Satellite Services, CC Docket No. 92-297, *Second Report and Order, Order on Reconsideration, and Fifth Notice of Proposed Rulemaking* (released March 13, 1997), at ¶309. ACE's success is proof that the operational capability for running user-friendly, efficient combinatorial auctions does in fact exist, and that such capability can and should be acquired by the Commission.

¹¹ See generally Part 1 Rulemaking, Comments of the Automated Credit Exchange (Mar. 27, 1997).

¹² 47 U.S.C. § 309(j)(3).

II. COMPARISON OF ALTERNATIVE BIDDING METHODOLOGIES

Section 309 (j)(12) of the Communications Act requires the Commission to compare the advantages and disadvantages of different competitive bidding methodologies established by the Commission.¹³ To this end, the Commission seeks public comment on the ability of the different methodologies to generate revenue and promote the efficient and intensive use of the electromagnetic spectrum.

A rigorous comparison of alternative bidding methodologies is impeded by the absence of a well-specified theoretical model that predicts the final assignment of licenses under bidding environments similar to those that exist in the Commission's spectrum auctions. In the absence of such a theory, ACE believes that statements comparing alternative bidding methodologies should be made with substantial care -- particularly with respect to methodologies, such as package bidding, that have not yet been tested by the Commission, and that may well prove to be superior to the Commission's simultaneous, multiple round system in a number of respects. For example, there is no obvious, theoretical basis for the Commission's assertion in the *Notice* that the current bidding methodology "generates the most information about license values during the course of the auction."¹⁴ Similarly, there is no obvious, theoretical basis for the assertion that the current methodology "provides bidders with the most flexibility to pursue spectrum aggregation strategies,"¹⁵ or the conclusion that "this methodology

¹³ 47 U.S.C. § 309(j)(12)

¹⁴ *Notice* at II.A.

¹⁵ *Id.*

effectively awards interdependent licenses to bidders who value them most highly.”¹⁶ Finally, there is no obvious, theoretical basis for the Commission’s prediction that the current methodology “is likely to yield more revenue than other auction designs.”¹⁷

Because of the incompleteness of existing theory, the only clear information regarding the comparative performance properties of alternative competitive bidding mechanisms of which ACE is aware comes from “economic experiments” conducted by researchers that have pioneered the development and analysis of such mechanisms. The information provided by these experiments paints a view of the comparative performance properties of the Commission’s current system *vis-a-vis* a package-bid system that differs substantially from the Commission’s general suggestions in the *Notice*.

A. Results Of Economic Experiments

Under the economic experiments methodology, markets are created in a laboratory setting using volunteer subjects and cash incentives to parallel the auction form being studied. Human subjects are paid according to how well they achieve their economic goals under the auction rules specified in the “experiment.” By changing the rules, researchers are capable of examining effectively different auction forms. Economic experiments have proven to be a useful tool both in testing a theory’s predictions as well as in presenting data on economic relationships where theory is substantially incomplete.

¹⁶ *Id.*

¹⁷ *Id.*

In the current context, an auction is a market process that uses bid prices to coordinate the preferences of its participants in an effort to reach an efficient assignment of the licenses being sold. The extent to which the auction must coordinate bidder preferences in order to obtain an efficient assignment depends, in part, upon the number of licenses up for auction, the extent to which different bidders desire the same licenses, and whether the combined value that a bidder placed on a collection of licenses is greater than the sum of its valuations for the component licenses. The larger the number of licenses up for auction, the greater the extent to which bidders value the same licenses, and the larger the amount of license value “synergy,” the greater the coordination demands imposed upon the auction.

Economists at the California Institute of Technology (Caltech), two of whom are ACE’s primary joint partners, have conducted a wide variety of economic experiments that examine the comparative performance properties of alternative auction mechanisms.¹⁸ While the results of their experiments do not span the entire range of important issues now before the Commission, they do shed significant light on a number of issues raised in the *Notice*.

In particular, Caltech has conducted comparative auction experiments involving numerous “valuation” environments.¹⁹ In the environments that appear to be most consistent

¹⁸ Most of these experiments have been conducted by Drs. John O. Ledyard and David Porter. Both researchers are intimately familiar with the unique problems associated with assigning spectrum licenses based upon their work on behalf of the National Telecommunications and Information Administration (NTIA) and the Commission.

¹⁹ For a discussion of some of the experiment results, see Ledyard, J.O., Porter, D., and Rangel, A., “Experiments Testing Multi-Object Allocation Mechanisms,” Preliminary Paper, 1997.

with the assignment of spectrum licenses, bidders experienced valuation synergies -- *i.e.*, license values are interdependent, such that the desirability of obtaining a particular license depends upon whether the bidder has also acquired one or more other licenses. Within the set of valuation synergy environments, Caltech has conducted experiments that impose varying performance challenges to the alternative auction methodologies.

1. Simple Fitting Environments

In the “simple fitting” environment, bidders experienced valuation synergies, but bidders did not differ substantially in the package of licenses that yielded such synergies (*i.e.*, packages did not substantially overlap).²⁰ In such an environment, the amount of overlap in bidder license preferences generated only a slight-to-moderate degree of contentiousness (or bidding competition) for commonly desired licenses.

Caltech examined two types of auctions in a simple fitting environment. The first was a simultaneous, ascending bid auction, which included activity, withdrawal, and stopping rules. The auction closely mirrored the mechanism the Commission used to assign its nationwide narrowband PCS licenses.

²⁰

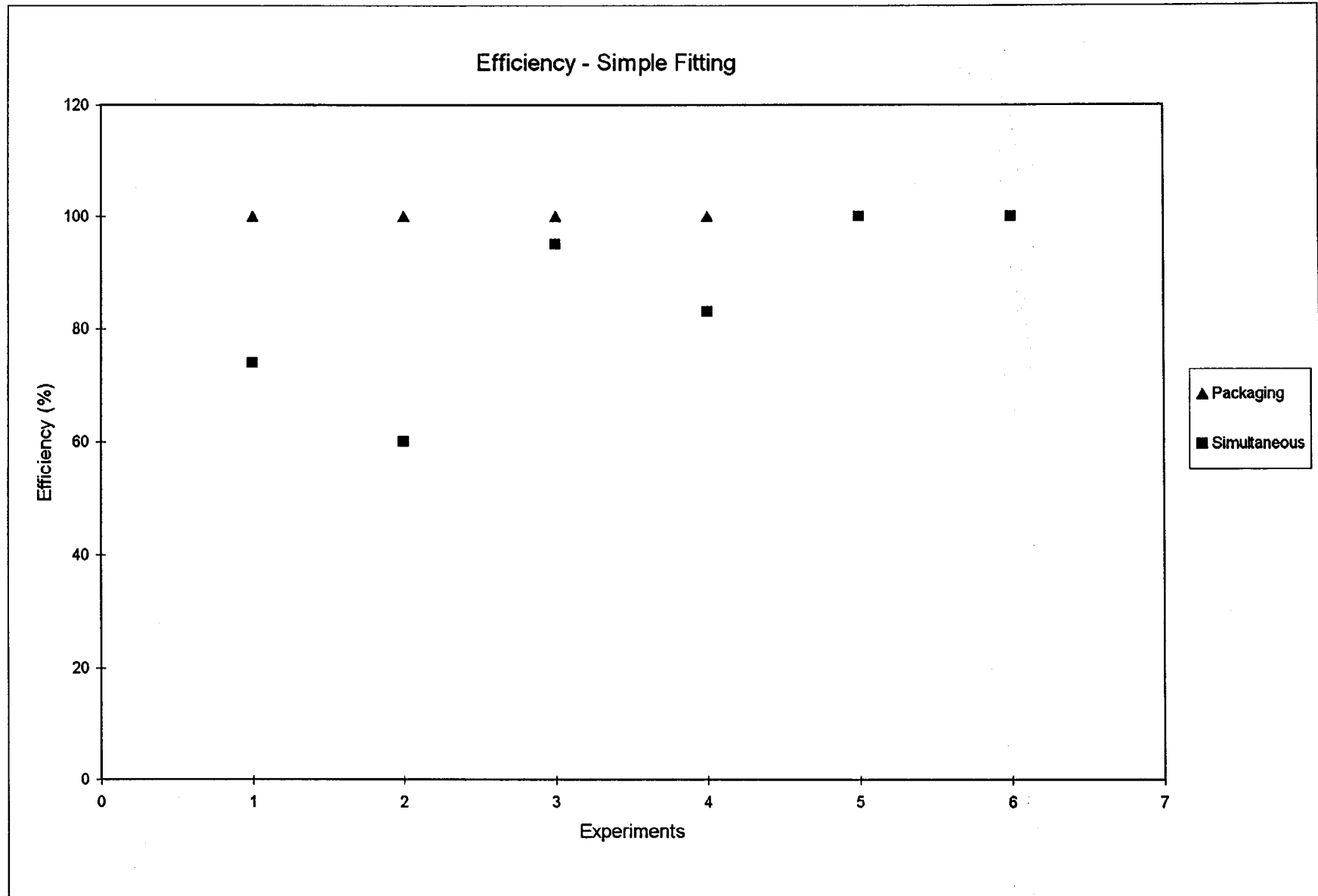
A “fitting problem” occurs when a bidder faces difficulty in assembling a collection of auctioned items that exhibit synergy values. The magnitude of this problem depends upon a variety of factors, including the amount of overlap or “commonality” in the bidder license preferences. Such overlap can increase bidding competition for a set of subset of the licenses that exhibit valuation synergies.

The second mechanism examined was a package-bid auction.²¹ In this auction, bidders were allowed, but not required, to submit bids for packages of licenses, as well as for individual licenses. Because it sometimes can take several small package or individual bids to displace a large package bid, the package-bid auction also used a bulletin board on which bidders could post “small” bids which, though are not large enough to displace a current winner, could become part of a collection of bids that, when summed, would be sufficient to displace the large bid.

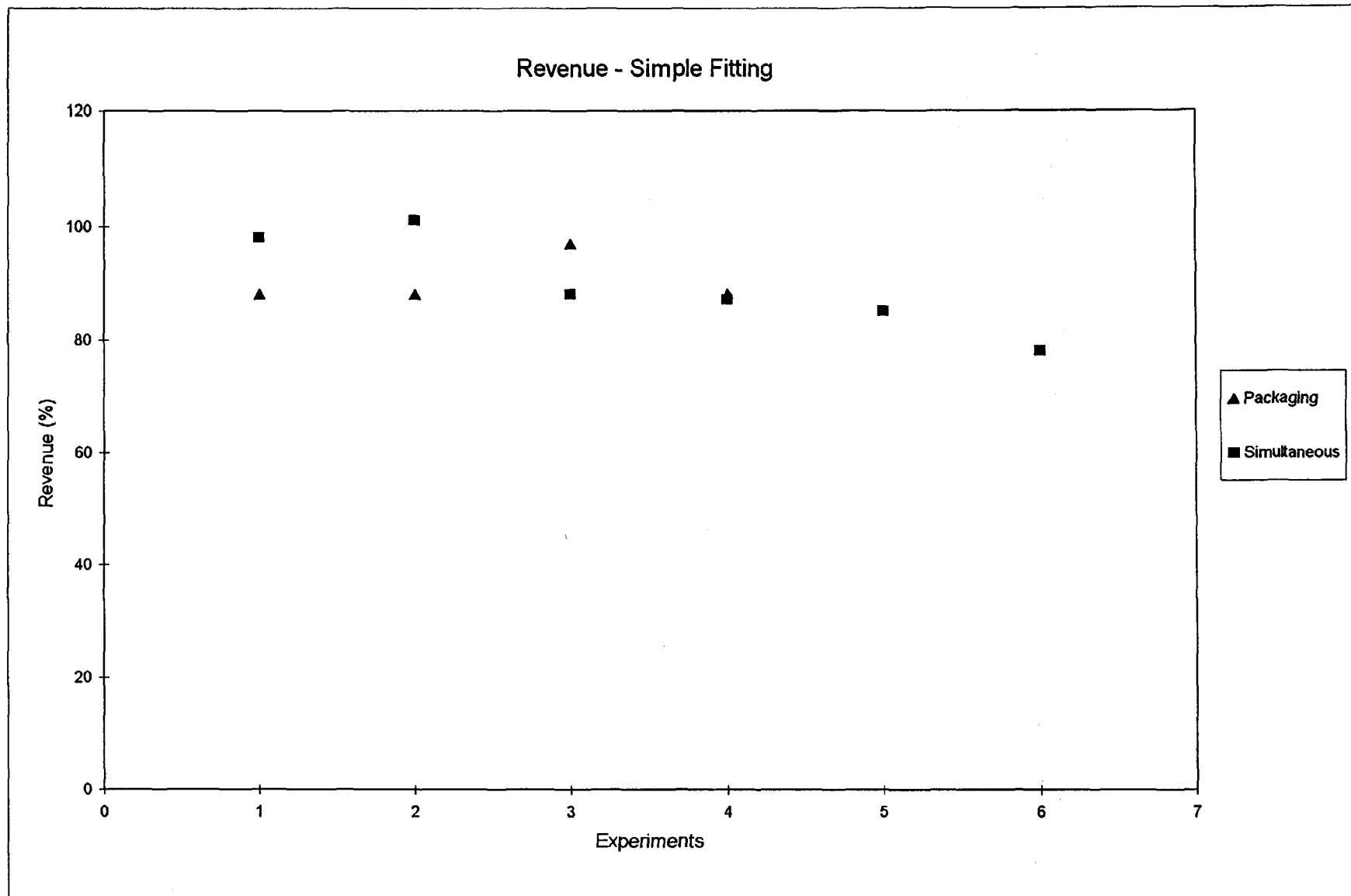
Graphs 1 and 2 compare the efficiency and revenue characteristics of the simultaneous and package-bid auction mechanisms. “Efficiency” is defined as the sum of the valuations that winning bidders placed on their licenses, divided by the sum of the valuations when the licenses were assigned to those that valued them the most. “Revenue” is defined simply as the dollars collected from the winning bidders divided by the sum of the valuations when the licenses were assigned to those that value them the most.

²¹ Technically speaking, a package-bid auction is also a “simultaneous” auction in that bidders are allowed to place bids in component sub-auctions.

Graph 1



Graph 2



Based upon the experimental evidence, both the simultaneous auction and the package-bid auction perform well in the simple fitting environment. Importantly, however, the evidence indicates that the package-bid auction will outperform a simultaneous approach both in terms of revenue and efficiency of the final assignment. On average, the package-bid auction generated an efficiency level of 100%, compared with 85% for the simultaneous auction. Similarly, the package-bid auction generated revenue that was 90% of the maximum value obtainable from the efficient assignment, compared with 89% for the simultaneous auction.

One finding of the Caltech experiments is particularly interesting. In some instances, the simultaneous auction generated revenue that exceeded the sum of the license valuations as measured by those that valued the licenses the most -- a result that indicates that one or more of the bidders paid more for their licenses than the licenses were worth. This phenomenon was unrelated to the "winner's curse," given that the economic experiment assumed that each bidder knew with certainty the underlying value of the license. Rather, the result occurred because the simultaneous auction failed to provide bidders sufficient ability, in instances where license-value synergies existed, to enter bids that represented gains to the buyers independent of the values (and consequently bids) other bidders placed on the auctioned licenses. On the other hand, if a bidder knew every other bidder's true valuation of each license and every set of licenses, then the bidder could calculate what bids to enter to avoid this problem. This is, of course, neither practical nor implementable due to the obvious incentive conflicts for bidders to enter their true values.

The Caltech experiments suggest that, because the licenses a bidder wins may alter the value of licenses another bidder wins, a bidder must estimate the value its competitors

place on certain licenses, and in doing so, take a financial risk when entering a bid for more than the license's "a la carte" value. In fact, it can be the case that a bidder actually *minimizes* his or her loss by paying *more* for the license than it is worth, rather than lose the license. For example, a bidder who values licenses A and B at 1 each, but values them together at \$5 is winning license A at \$3 and losing B at \$2, therefore generating a loss in A of \$2. If the bidder pays \$3 to win license B, then it generates a loss of only \$1, since licenses A and B together are worth \$5 and the bidder paid \$6. Of course, allowing bidders to default reduces their incentives to minimize losses. If an aggressive bidder underestimates the value that competitors place on certain licenses, it may cause the bidder to pay more for the license than it is truly worth.²²

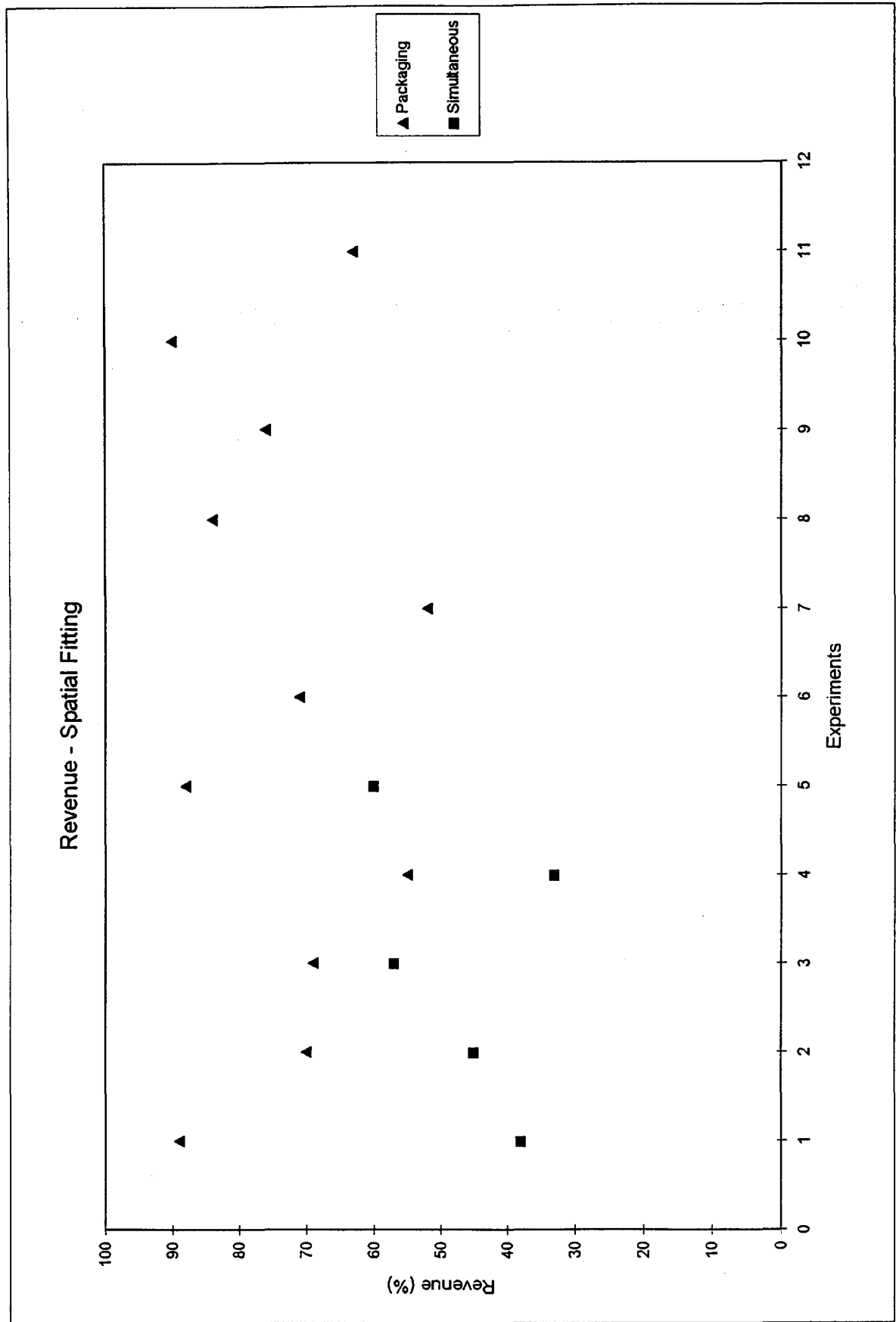
2. **Spatial Fitting Environment**

Caltech also examined the auction methodologies in a "spatial fitting" environment. The principal difference between this and the simple fitting environment is that there is significantly more partial overlap in license package preferences among bidders. The greater overlap in preferences results in increased bidding competition for selected licenses and, therefore, more uncertainty for bidders. Graphs 3 and 4 compare the efficiency and revenue characteristics of the two auction mechanisms.

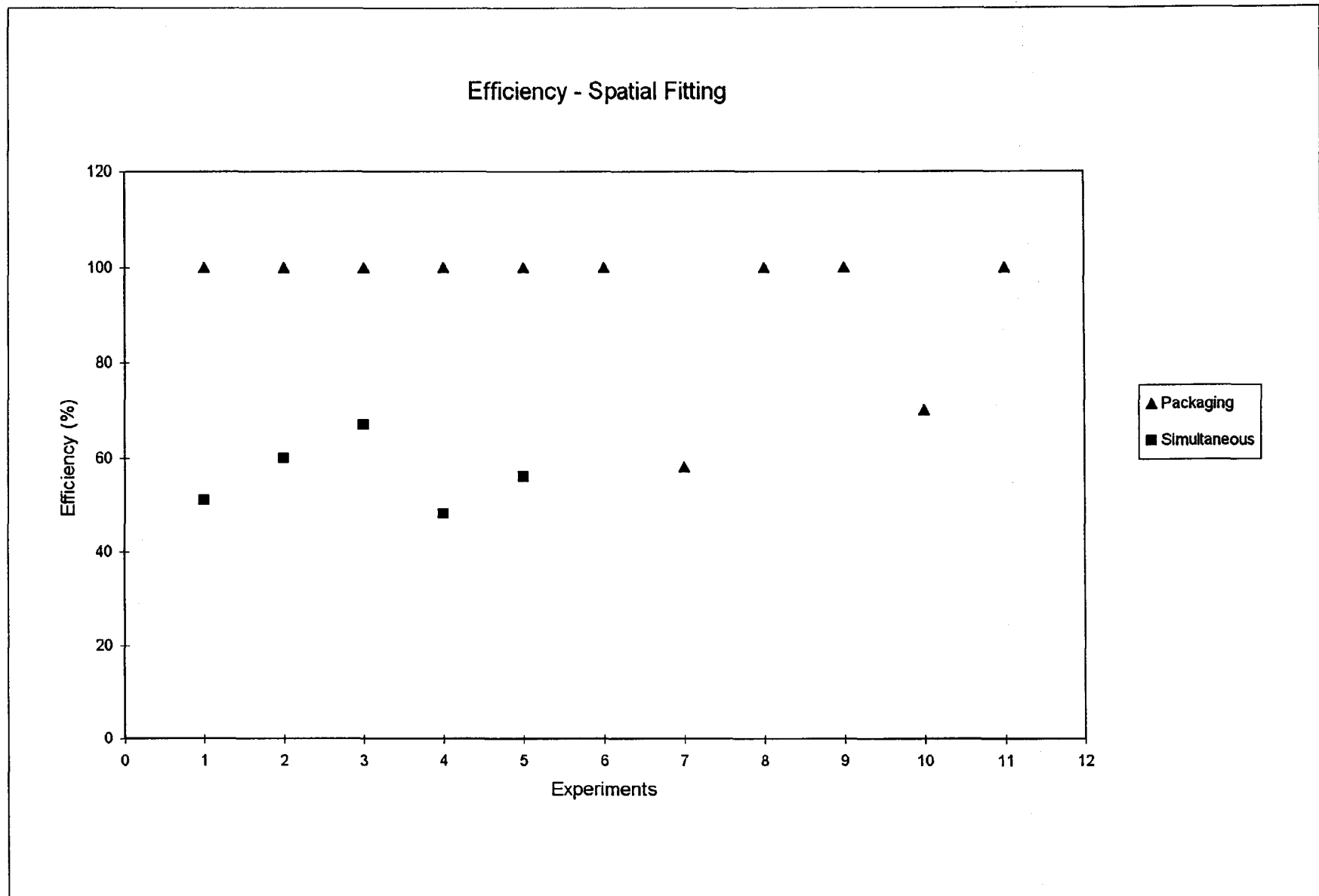
²²

For a description of how this may happen, See Bykowsky, M., Cull, R., and Ledyard, J.O., "Mutually Destructive Bidding: The FCC Auction Design Problem," Caltech Social Science Working Paper, #916, January 1995.

Graph 3



Graph 4



As shown in Graph 3, a package-bid auction is superior to a simultaneous auction in both revenue generation and assignment efficiency. On average, the package-bid auction generated an efficiency level of 93%, compared with 56% for the simultaneous auction. Efficiency is enhanced because bidders can find and bid on those packages with valuation synergies *without bearing the financial risk associated with losing an element of the package that contributes importantly to the synergy value*. The elimination of this so-called “financial exposure” risk enhances, relative to a simultaneous auction, the amount of “value” information generated in the auction and, in so doing, leads to improvements in efficiency.

The package-bid auction generated revenue that was 73% of the maximum value obtainable from the efficient assignment, compared with 46% for the simultaneous auction. The explanation for the superior revenue generating ability of a package-bid auction is straightforward. The revenue generated in an ascending-bid auction depends upon the level of the second highest bid. Package bidding generates more revenue, on average, because it generates higher second-highest bids due to its superior ability to generate valuation information. Such bids are higher because the package-bid auction eliminates bidders’ concerns about financial exposure.

III. SMALL BUSINESS ADVANTAGES WITH A CONTINGENT, COMBINATORIAL AUCTION

One of the difficulties with a simultaneous, simple bid auction (the type currently run by the Commission) is that bidders are put at financial risk if either 1) the bidder desires any one of several licenses, and is willing to pay to win any one of these licenses, but the bidder does not desire more than one license; or 2) the bidder desires a “package” of licenses -- a group of

licenses that if combined has a value to the bidder that is greater than the sum of the values of the group's parts.

In both the above situations, small businesses can face significant financial risk -- both in failing to obtain the licenses best suited for their needs, and in paying too much for the licenses that they do obtain. For several reasons, small businesses with more limited financial resources are more likely not to win their preferred licenses under a simultaneous, non-packaged bid auction, even in cases where they are able to pay more than the eventual winning bids.

Example 1: Bidder Desires a Package of Licenses

Suppose that a bidder has the following values for licenses.

A=\$5

B=\$1

C=\$1

A, B, & C (together) = \$10

The bidder is faced with a dilemma. How much does it bid for A, B, and C -- whose value of the licenses collectively (\$10) is worth more than the sum of individual license values (\$7) -- knowing that it may get only one or two of the licenses? Both large and small business face this dilemma under the Commission's current auction design, but the more limited financial resources of small businesses exacerbate the potential for harmful effects on those

entities. Further, larger businesses can often afford to hire auction theorists to guide them through the auction's strategic elements -- an expense more difficult for small business to incur.

If the bidder does not have the financial wherewithal to incur financial losses in the auction, then it cannot afford to risk bidding more than \$5, \$1, and \$1 for licenses A, B, and C, respectively -- a total of \$7. By contrast, a larger company (or several companies) may have values for license A at \$6, license B at \$1 and license C at \$2. Although the small bidder values these licenses together at \$10, it is unable to enter a bid as such without taking significant financial risk, that it will get "stuck" with less than the entire package and wind up paying more than it would otherwise pay for individual licenses. To have a chance to win the package that maximizes value to the bidder, the bidder would have to bid more than its stand-alone value for licenses A and C in order to obtain the package of license A, B, and C. Without, however, knowing the true values the other bidders place on these licenses, the bidder will face financial risk in placing such bids, since the bidder does not know whether his bids for all the licenses in the package will indeed be the winning bids at the end of the auction. The bidder understands that the possible result of bidding more than its standalone value for each of the licenses is that the bidder receives only one or two of the licenses and therefore pays too much for those licenses (too much is more than the stand-alone value for the licenses, since the bidder did not receive all three). The result is that the small business has less ability and incentive to bid what would otherwise be the most efficient (and revenue maximizing) auction outcome.

Example 2: Bidder Desires One of Several Licenses

While the withdrawal rule is intended to help limit certain types of financial exposure for bidders, a withdrawn bid can be accompanied by financial penalties. Under the current auction form, there are clearly instances where under a withdrawal rule, switching bids on licenses carries an uncertain penalty since the bidder does not know the amount of the second highest bid that will remain. The following example illustrates the affect of this auction rule -- which likely is necessary given the simultaneous, non-package bid auction form utilized by the Commission -- on the available strategies of bidders.

Suppose that a bidder desires either license A or license B, and values these licenses at \$6 and \$4 respectively. The bidder does not have financing to purchase both licenses.

Suppose that the bidder submits a bid of \$5 for a license A and is the round's winning bidder. The winning bid for license B was \$4, thus making A the better license for the bidder, but the winning bid for license B was later withdrawn, and the next highest bid for the license was \$2. The bidder would be better off bidding on and winning B, but would have to withdraw his or her bid on license A. Because of the uncertain potential penalties, it is financially risky for the bidder to reveal a preference for license B by withdrawing the bid on A and replacing it with a bid on B. The end result is that the bidder wins a license that is not the most financially sound investment for the bidder, and is likely not part of the efficient allocation for the auction.

An auction that allowed packaged bids does not need a withdrawal rule in order to protect against the financial exposures associated with attempts to aggregate licenses. Adding the opportunity to enter contingent “OR” bids (allowing bidders to enter several bids on different licenses, or packages of licenses, and specify that at most one of the bids could be part of the winning license assignment) would remove the problems described in the above two scenarios.

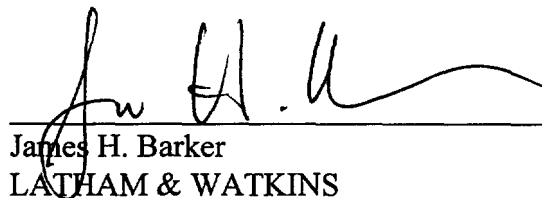
There are many examples where bidders’ inability to enter “package” bids and contingent “OR” bids places the bidders at risk. In most cases one can argue that the risks are greatest for the small companies who do not have internally generated capital or have more limited access to lower cost capital. This risk and complexity could be removed using an auction design that allows both packaged bidding and contingent bidding, to the benefit of small bidders and those who finance them.

IV. CONCLUSION

The Commission’s rules should encompass package bidding specifically as a design alternative for the Commission to allocate licenses using competitive bidding. The present review of the Commission’s auction successes and areas for improvement provides an opportune moment for the Commission to actively explore this bidding methodology. ACE urges the Commission to consider and implement this method of auctioning as soon as possible, even if its first step is a “pilot” or test auction. The benefits of package bidding are real and proven, and should be extended to the public at large through the spectrum auction process.

August 1, 1997

Respectfully submitted,

A handwritten signature in black ink, appearing to read "J. H. Barker", is written over a horizontal line.

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